Iikka Hyvönen, Nuutti Vuorimies, Pauli Kolisoja

ROAD 16583 EHIKKI-JUOKSLAHTI

Demonstration of a Possible Drainage Solution for an Eroding Sideslope and Ditch

Demonstration Project Report

ABSTRACT

Rutting of the road surface due to the development of permanent deformations, both in the road structure itself and in the underlying subgrade, is in most cases the dominant distress mechanism on low volume roads of the Northern Periphery area.

From a road users' point of view rutting both lowers driving comfort and reduces traffic safety. This is particularly the case when surface water is trapped in ruts, thereby increasing the risk of aquaplaning in summertime and of icing in the wheel path in winter when temperatures fall below 0°C. In addition, rutting can also be very harmful to the structural condition of the road, as it speeds up water infiltration into the road structure, increasing the effects of dynamic wheel loads etc.

Rutting can develop in a road for a number of reasons. It may develop in the structural layers due to poor quality material, or as a result of poor drainage making the material more susceptible to permanent deformations. It may also develop in a weak subgrade material if the overall thickness of the structural layers is low. This is a very typical situation on the low volume roads of the Northern Periphery area, particularly during the spring thaw where the subgrade material is frost-susceptible. Rutting mechanisms are discussed in greater detail in the ROADEX reports available at www.roadex.org, together with a new method of classifying rutting modes.

This report describes a ROADEX demonstration exercise carried out on a low volume road section of Road 16583 from Ehikki-Juokslahti in Jämsä, Central Finland. The work comprised a drainage improvement of a low volume road site suffering from spring time bearing capacity problems. The rehabilitation structure consisted of a geotextile and layer of coarse grained aggregate installed into a cleaned and prepared roadside ditch. The idea of this solution was to prevent the fine-grained slope and subgrade material from collapsing and eroding into the ditch and thus lead to bearing capacity loss of the road due to an inoperative drainage This phenomenon had been occurring regularly on the demonstration site, especially during the spring thaw, as the slope and subgrade material were very frost-susceptible.

Now, after experiencing the first spring thaw, the improved drainage system has been found to be in excellent condition. In addition, there were no spots on the road that had significant spring time bearing capacity loss, unlike the situation before the drainage improvement. This was despite the fact that a nearby site with basically similar conditions, but without the ROADEX drainage improvement, was already showing signs of reclogging of the ditch after the first spring thaw cycle.

KEYWORDS

Rutting, permanent deformation, rehabilitation, low volume road, drainage, geotextile, Northern Periphery

PREFACE

Tampere University of Technology has been responsible for the design, follow up and documentation of a number of demonstration sites carried out under the ROADEX project task D4 ‘Rutting, from theory to practice’. These demonstration sites showcase innovative ROADEX solutions to various types of rutting problems on low volume roads of the Partner areas. This report presents the early results from the demonstration site located on Road 16583 Ehikki-Juokslahti in Jämsä, Central Finland. On this site a section of low volume road was rehabilitated by improving its drainage system using an innovative slope protection structure consisting of a geotextile and a layer of coarse grained aggregate installed on top of it. The idea of this solution was to protect the side ditch from being clogged by frost susceptible material from the slopes eroding into the ditch especially during the spring thaw.

The report has been compiled by Iikka Hyvönen and Nuutti Vuorimies under the supervision of Pauli Kolisoja, all from the Laboratory of Earth and Foundations Structures at the Tampere University of Technology, TUT.

Special thanks are given to Heikki Parviainen from the Centre of Economic Development, Transport and the Environment of Finland. Without his open-mined attitude on the new ROADEX solutions the demonstration sites in Jämsä area would have never been realised. Equally important has been the co-operative attitude of the staff of the contractor Destia Ltd, especially that of Jukka Järvenpää.

Petri Varin from Roadscanners Ltd organised the GPR measurements and analysed the results. Ron Munro from Munroconsult Ltd checked the language.

Finally, last but not least, the authors would like to thank the ROADEX IV Project Steering Committee for their guidance and encouragement during the work.

ROADEX “Implementing Accessibility” Lead Partner: The Swedish Transport Administration, Northern Region, Box 809, S-971 25 Luleå. Project co-ordinator: Mr. Krister Palo.

CONTENTS

1. INTRODUCTION

1.1 THE ROADEX PROJECT

The ROADEX Project is a technical co-operation between road organisations across northern Europe that aims to share road related information and research between the partners. The project was started in 1998 as a 3 year pilot co-operation between the districts of Finland Lapland, Troms County of Norway, the Northern Region of Sweden and The Highland Council of Scotland and was subsequently followed and extended with a second project, ROADEX II, from 2002 to 2005, a third, ROADEX III from 2006 to 2007 and a fourth, ROADEX "Implementing Accessibility" from 2009 to 2012.

Figure 1.1 *The Northern Periphery Area and ROADEX IV Partners*

The Partners in the ROADEX "Implementing Accessibility" project comprised public road administrations and forestry organisations from across the European Northern Periphery. These were The Highland Council, Forestry Commission Scotland and the Western Isles Council from Scotland, The Northern Region of The Norwegian Public Roads Administration, The Northern Region of The Swedish Transport Administration and the Swedish Forest Agency, The Centre of Economic Development, Transport and the Environment of Finland, The Government of Greenland, The Icelandic Public Roads Administration and The National Roads Authority and The Department of Transport of Ireland.

The aim of the project was to implement the road technologies developed by ROADEX on to the partner road networks to improve operational efficiency and save money. The lead partner for the project was The Swedish Transport Administration and the main project consultant was Roadscanners Oy of Finland. The project was awarded NPP funding in September 2009 and held its first steering Committee meeting in Luleå, November 2009.

A main part of the project was a programme of 23 demonstration projects showcasing the ROADEX methods in the Local Partner areas supported by a new pan-regional "ROADEX Consultancy Service" and "Knowledge Centre". Three research tasks were also pursued as part of the project: D1 "Climate change and its consequences on the maintenance of low volume roads", D2 "Road Widening" and D3 "Vibration in vehicles and humans due to road condition". All of the reports are available on the ROADEX website at www.ROADEX.org.

1.2 THE DEMONSTRATION PROJECTS

Twenty three demonstration projects were planned within the ROADEX IV project. Their goal was to take selected technologies developed by ROADEX out on to the local road networks to have them physically used in practice to show what they could achieve. The projects were funded locally by the local Partners, designed an supervised by local staff, and supported by experts from the ROADEX consultancy.

The demonstrations were managed in 6 groups by a nominated lead manager from ROADEX:

D1 - “Drainage Maintenance Guidelines”, lead manager Timo Saarenketo

D2 - “Road friendly vehicles and Tyre Pressure Control”, lead manager Pauli Kolisoja

D3 - “Forest Road policies”, lead manager Svante Johansson

D4 - “Rutting, from theory to practice”, lead manager Pauli Kolisoja

D5 - “Roads on Peat”, lead manager Ron Munro

D6 - “Health and Vibration”, lead manager Johan Granlund

1.3 D4 “RUTTING, FROM THEORY TO PRACTICE”

The aim of the ‘Rutting, from theory to practice’ task was to demonstrate the practical applications of innovative ROADEX solutions in the rehabilitation of low volume roads suffering from permanent deformation problems in the Partner areas. The leading idea in the demonstrations was to use ‘fit for purpose’ solutions selected after a sound analysis and understanding of the reasons behind the problems encountered on the individual sites. As the name of task suggests, the main focus was on those problems that appear in the form of permanent deformations, i.e. rutting, which can be the result of different forms of underlying mechanisms. These mechanisms are dealt with in greater detail in a range of ROADEX reports available at www.roadex.org.

The first stage in the problem analysis of each site was to develop a clear understanding of the deterioration mechanisms at work using simple, low cost means of investigations, such as visual observation. This was then supplemented, when required, by Ground Penetrating Radar (GPR) measurements, easy to use site investigation methods, e.g. the Dynamic Cone Penetrometer (DCP) test, and some basic laboratory tests like grain size distribution analysis and Tube Suction (TS) tests. More sophisticated laboratory investigations were not used as these are seldom available to the ROADEX Partners due to the limitations of both budget and time.

All of the demonstrations were carried out as part of scheduled road rehabilitation projects by the local ROADEX Partners, and in practice this meant that some operational adjustments were necessary to suit their needs, i.e. none of the demonstrations were carried out just for the ROADEX project alone. This fact naturally set some limitations for the design of the demonstrations, particularly with regard to the available time for preliminary investigations, but this was accepted to be a normal fact of life in practice for most Partner roads operations, and in fact added realism to the work.

2. DESCRIPTION OF ROAD

2.1. LOCATION

Road 16583 is located in the middle part of Finland about 45 kilometres south-west from Jyväskylä. The road's Location is shown in Figure 2.1 and the test section is identified with the red circle.

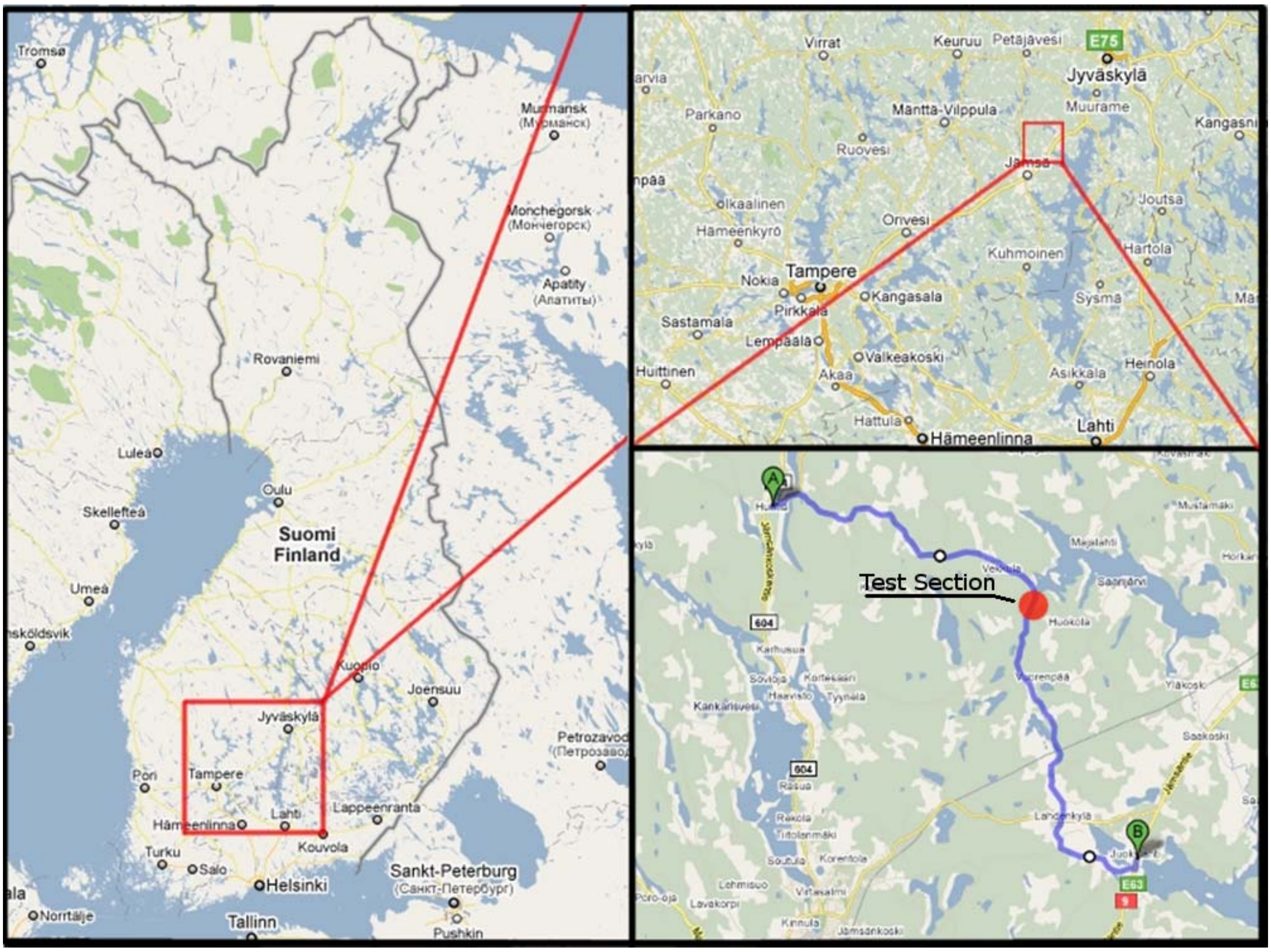


***Figure 2.1** Location of Road 16583 Ehikki – Juokslahti (Google Maps)*

2.2. TRAFFIC

Road 16583 connects the two small villages of Ehikki and Juokslahti. Typical road users are local inhabitants, farmers and logging trucks. The traffic volume is low. The Annual Average Daily Traffic (AADT) is only 48 vehicles per day for the first and second part of the road (1/0 – 3/5207) and 156 vehicles per day for the third part of the road, which is located at the eastern end of the road (3/5207 – 6886) [1]. Although the traffic volume is low, the road is important to logging companies. In the future there will be an increase in logging in the surrounding areas and this is one of the reasons that the road was scheduled for improvement now.

2.3. ROAD STRUCTURE

Road 16583 Ehikki-Juokslahti is a 20.5 kilometres long unpaved gravel road. It is a gravel road throughout except for a short section with asphalt pavement on the second part of the road. This asphalt pavement section is only 200 metres long and located on the approaches to a railroad bridge. Road 16583 is a typical example of a gravel road in Central Finland and there are many other roads like it across Finland. It has all the typical features of gravel roads: narrowness, hilliness and lots of curves. Other typical features are sections of side sloping profile and the closeness of adjacent fields and lakes.

2.4. LOCAL LANDSCAPE AND TERRAIN

Road 16583 passes through a variable topography of hills, hummocks, lakes and peat-lands between hills, which creates challenging circumstances for the road. An example of this topography is shown in Figure 2.2. This range of topography results in the road, having a range of different features, such as side sloping ground and morainic hummocks. The terrain is mostly frost-susceptible morainic soil and in some places the bedrock is close to the surface.

Figure 2.2 *Topography of the area*

Figure 2.3 Water erosion on the road

Figure 2.4 *Water erosion*

2.5. ROAD PROBLEMS

The condition of road 16583 is generally good for most of the year, but problems can appear during springtime. These are generally caused by spring thaw weakening which can be divided into two phases.

Phase 1: When the air temperature rise above zero the surface thaw weakening phase starts. This causes softening of the wearing course making it plastic. The higher the fines content, the greater is the plasticity of the road's surface. The road then becomes slippery and uncomfortable to drive.

Phase 2: As the air temperatures keep rising the frost thaws deeper into the road and the structural thaw weakening phase starts. The thawing frost produces excess water in the lower structure and subgrade. If the subgrade has low water permeability it may become plastic causing permanent deformations with Mode 2 rutting, the subject of this report. In addition the passage of heavy vehicles can create increased hydrostatic pressures which can force excess water to flow up and to the side. As a consequence of this damaged roads sections which have suffered structural thaw weakening can also experience embankment widening to the ditches. [2]

Figure 2.5 *Damages of the road in the Spring*

3. DATA COLLECTION / AVAILABLE DATA

3.1. FIELD INVESTIGATIONS

3.1.1. Site Investigation

Normally site investigations are carried out only once for a road rehabilitation but in this site they were carried out twice. The first site investigation was carried out during the spring thaw process in April when road damages could be seen. The second visit, the 'official' site investigation, took place in the beginning of June 2010 when the road was in better shape and only severe damages remained. Inventory photos were taken during this investigation and the damaged sections of drainage systems were checked for location and condition.

Figure 3.1 *Filled up ditch in the beginning of the summer*

3.1.2. GPR Measurements

Ground Penetrating Radar (GPR) measurements were taken with Roadscanners three dimensional 3D-radar. Measurements were carried out in one direction during winter 2009-2010. The resulting longitudinal GPR interpretations are shown in Appendix 1. According to the GPR measurement the road structure comprised a 0.65 m thick wearing course and a 0.3 m base layer. Neither bedrock nor large rocks were detected in the interpretations.

Interpreted cross-sections were made for chainages 2/3360, 2/3400, 2/3430 and 2/3460. The interpretations of these cross-sections are shown in Appendix 2.

GPR is a non-destructive method to investigate road structures. It is based on short electromagnetic pulses which are transmitted into the road. These travel, reflect and refract as they meet changes (e.g. surface layers) in dielectric properties. GPR equipment consists of a transmitter and receiver electronics, which are connected to an antenna and a central unit to control the data collection and store the collected data. Through the antenna an electromagnetic pulse is sent into the ground. A part of the energy of the pulse reflects back when there is a change in material electrical properties, and a part goes through this material and reflects from the next surface, etc. Electric conductivity and dielectric value are the main parameters that affect the GPR signal. The signal attenuates as a function of travel time due to geometrical spreading, scattering, reflections and thermal loss. A high amount of fine materials and salt in the structure increases electric conductivity. This weakens the GPR signal and diminishes its ability to penetrate further. The GPR data collection system records travel time and amplitude of the pulses, which are then displayed. When these measurements are repeated, it is possible to present a continuous profile of the analysed structure. [3]

3.2. LABORATORY INVESTIGATIONS

No laboratory investigations were carried out in this demonstration project.

4. PROBLEM ANALYSIS

4.1. DIAGNOSIS OF THE PROBLEMS ON SITE

Open ditches are the most common kind of drainage measure on low volume roads. The function of open ditches is to drain both surface water from the road surface and water from within the road structure. It is usually recommended that the depth of the ditch should be 0.30 to 0.35 m below the road structure to enable it to function properly. [4]

The main defect in the test section was that the road had widened towards the ditch as discussed in Section 2.5 and that the outer slope had become too steep. This had resulted the outer slope becoming unstable and collapsing in to the ditch especially during the spring thaw. Without cleaning, the ditch had filled with mud and vegetation, as shown in Figure 4.1. As a consequence of this the drainage capacity of the ditch had reduced, causing the ground water table to rise in the road structure and reduce the bearing capacity of the road. (A secondary effect of the rise in the ground water table is an increase in the risk of frost heave damage.)

Figure 4.1 *Steep slope and filled up ditch*

5. REHABILITATION SOLUTION

The main problem identified on the section of road surveyed was an unstable outer embankment slope coupled with poor drainage resulting from mud and vegetation filling the roadside ditch.

A test rehabilitation exercise was proposed for a test section of 100 metres using a solution suggested in the ROADEX II report "Drainage on Low Traffic Volume Roads" by Berntsen and Saarenketo (2005). The rehabilitation structure is shown in Figure 5.1.

5.1. PROPOSED REHABILITATION STRUCTURE, CHAINAGE 02/3360-3460

The rehabilitation solution comprised:

- Removal of the old banking material + clearing of the ditch + shaping
- Installation of a separation geotextile
- Stabilisation with 250 mm coarse graded aggregate

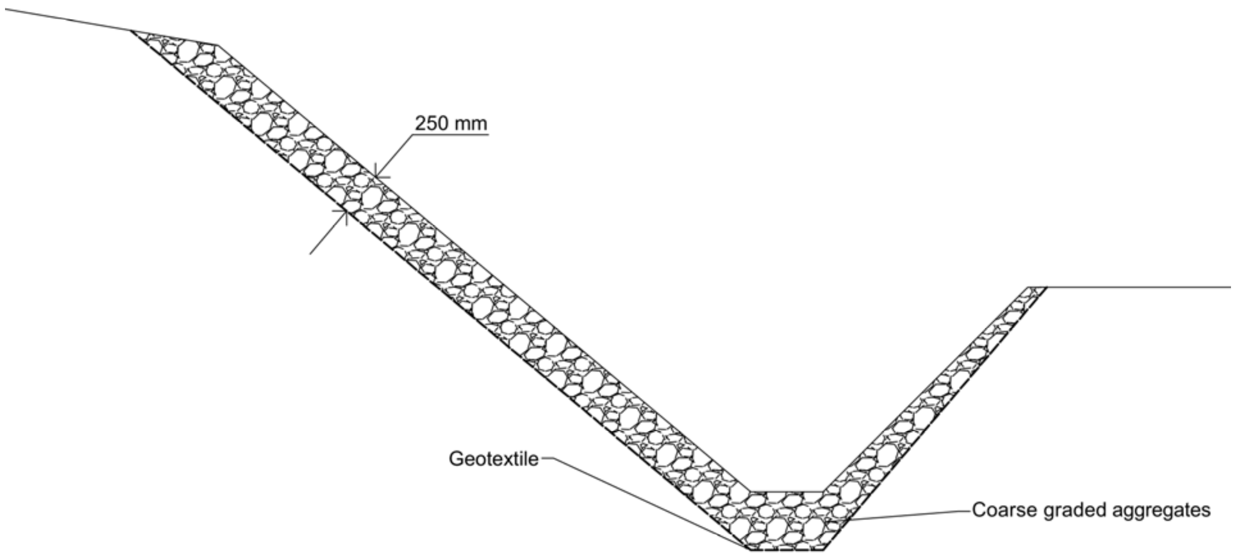


Figure 5.1 *The Rehabilitation Structure*

5.2. RATIONALE FOR THE SELECTED SOLUTION

The subsoil in the test section was a frost susceptible fine graded silt or silty moraine and that needed ditch clearing more frequently than normal. Improving the slope stability of the outer slope with a geotextile and coarse aggregate will reduce the potential for the slope to collapse and erode. Fine graded soils have a low bearing capacity at high moisture content and require a well working drainage system to perform at their best. [4]

6. DESCRIPTION OF THE REHABILITATION WORKS

The rehabilitation works were commissioned by the ELY Centre of Central Finland. The contactor was Destia. The works at the test section started early in the morning 1st of September 2010 and were finished by the evening of the next day. The weather condition during the works was variable but mainly good. At the beginning of the work the weather was cloudy and the temperature was +10° Celsius. There were occasional rain showers, but these did not disrupt the works. The working methods used at the rehabilitation works are described in the following section.

6.1. WORKING METHODS

The work on site started with clearing the debris from the ditch and removing the vegetation, as shown in Figure 6.1. At the same time the excavator shaped the slope and the ditch. Two men, an excavator and earth-hauling truck were used on this part of the work.

Figure 6.1 *Clearing the ditch and removing the vegetation*

As the excavator cleared the ditch, the selected geotextile was laid on to the newly shaped ditch and slope. The geotextile was first rolled on the field and cut into smaller lengths to facilitate easier handling by one man, as shown in Figures 6.2, 6.3 and 6.4.

Figure 6.2 *Cutting the geotextile*

Figure 6.3 *Installing the geotextile*

Figure 6.4 *Installed geotextile*

At the end of the first day, the geotextile was installed and ready to receive the coarse graded material. A small amount of aggregate was laid on the geotextile to hold it down overnight as a precaution against wind damage, as shown in Figure 6.5.

On the second day the installation was completed by laying the rest of the coarse graded aggregate on top of the slope and ditch sides. One earth-hauling truck was used for the operation and took the whole day. An excavator finished the work by shaping and compacting the aggregate with its dipper arm. The finished installation is shown in Figure 6.6.

Figure 6.5 *Adding some aggregate as a precautionary weight*

Figure 6.6 *The finished installation (02.09.2010)*

6.2. PROBLEMS ENCOUNTERED ON SITE

The works did not encounter any major problems on site. Nearby logging areas caused some minor traffic problems on the narrow road that required the excavator and earth-hauling truck to halt their work for a moment to let the logging trucks pass, as shown in Figure 6.7. Another minor issue was the presence of an overhead electric line close to the ditch. The excavator operator had to be careful not to damage the line with the boom. The electric line was immediately above the ditch from chainage 02/3360 to 02/3400 and the excavator had to work under this section of line.

Figure 6.7 *Passing logging truck*

6.3. OTHER REMARKS

Working efficiency on the site was not the best possible. The excavator had to wait almost every cycle for the earth-hauling truck to travel to the dumping ground to empty its load. Luckily a local farmer needed landfill and this minimised the cycle time. The distance to the alternative dumping ground was 8.5 km from the worksite. With two earth-hauling trucks the work could have been much faster.

7. SITE MONITORING

7.1. RECOMMENDATIONS FOR FUTURE MONITORING

It is recommended that the performance of the test structure is monitored in the future to enable some conclusions to be made on the effective of the work done. This can be done by means of a simple site visit and visual inspection.

7.1.1. Site investigation

The site should be inspected and photographed after the freeze-thaw cycles in the spring. It has been proven that the major part of road damages develops during the spring and any damages incurred are likely to be more visible at this time.

An initial site investigation was carried out on 5th of May 2011 after the spring thaw. The road was found to be in good condition and the drainage was also found to be working without any problem. The condition of the road on the day of the inspection is shown in figure 7.1. No areas of marked bearing capacity loss could be observed, unlike the case before the drainage improvement. A site investigation was also carried out in a rainy day on 24th of November 2011. The road was found to be in good condition as shown in figure 7.2.

Evidence of the success of the drainage improvement structure could be seen on a nearby site originally considered as an alternative location for the drainage demonstration. On this site the ditch had been cleaned out in the normal way, i.e. without using the ROADEX solution of geotextile and coarse grained aggregate, and there were already clear signs visibile of the side ditch starting to be fill up after the first spring thaw (figure 7.3).

Figure 7.1 *The test section after the first spring thaw (05.05.2011)*

Figure 7.2 *The test section on late autumn (24.11.2011)*

Figure 7.3 *Initiating reclogging of the side ditch on a nearby site after the first spring thaw cycle.*

The parameters that should be monitored in future site investigation are weather conditions, temperature and information regarding heavy traffic. These will have an effect on the condition of the road.

8. CONCLUSIONS

This report describes a ROADEX demonstration exercise carried out on a low volume road section of Road 16583, Ehikki-Juokslahti, in Jämsä, Central Finland that was suffering from roadside drains that were regularly being clogged by material eroding from the slopes.

A drainage improvement was executed using a ROADEX solution consisting of a geotexile and layer of coarse grained aggregate. This was placed on top of the sides and base of the ditch after it had been cleaned of mud and vegetation.

The idea of the solution was to prevent the material from the fine-grained slope above the road from collapsing and eroding into the ditch. This phenomenon had regulary been taking place on the road section, especially during the spring thaw, and had led to a bearing capacity loss on the road due to the drainage system being inoperable,

Now, after the first spring thaw, the improved drainage system has been found to be in excellent condition with no areas of marked spring time bearing capacity loss on the road, unlike the situation before the drainage improvement. This is despite the fact that on a nearby site, with basically similar conditions but with the ditches cleaned out in the normal way, there were already signs of reclogging of the ditch after the spring thaw cycle.

REFERENCES

1. Tierekisteri (Road Data Bank) Cited: 9.7.2010

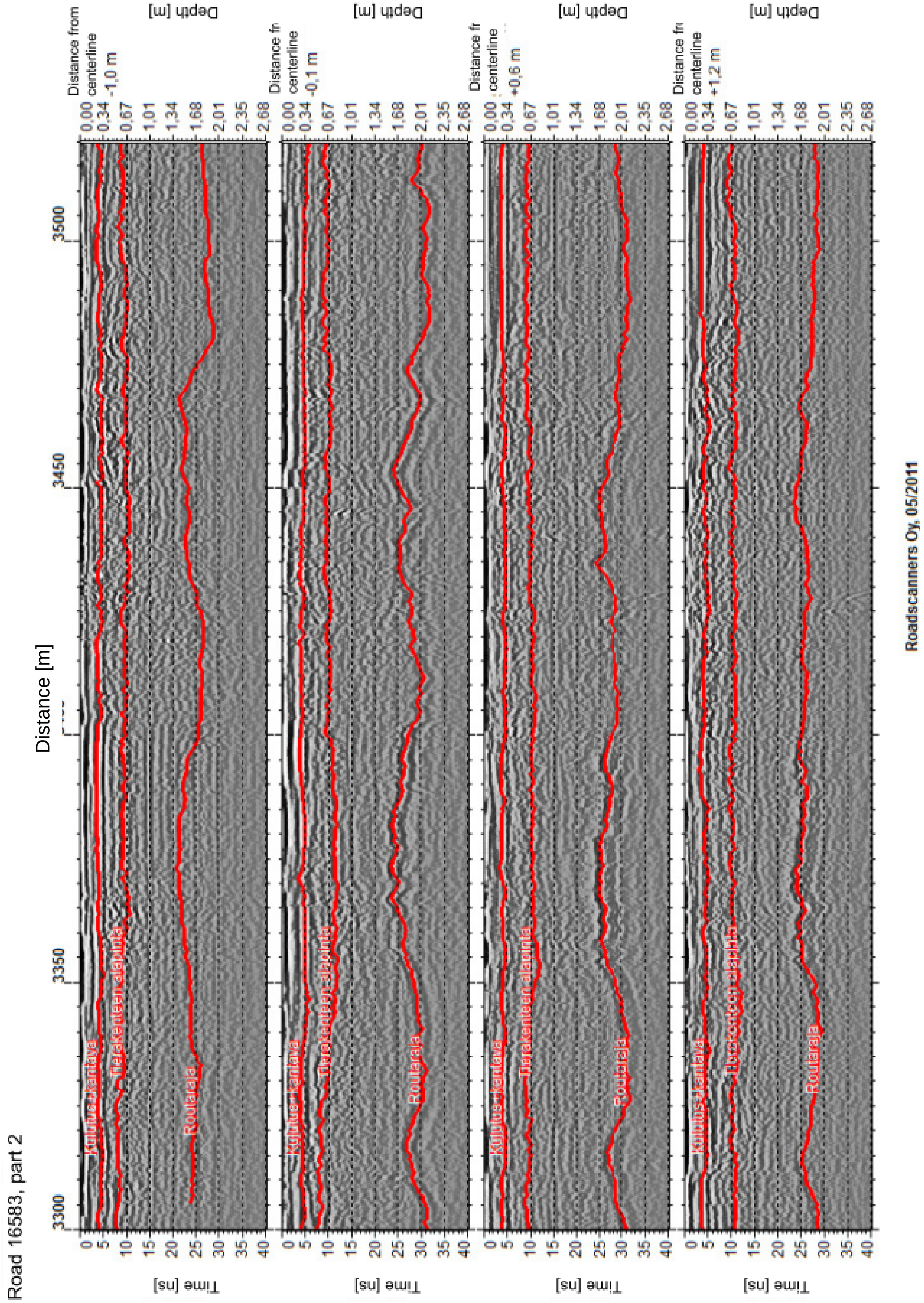
2. Saarenketo, T., Aho, S. (2005). Managing Spring Thaw Weakening on Low Volume Roads, Roadscanners Oy 2005

3. Matintupa, A. (2009). AC 1093 Morkan-Dikanäs, Rehabilitation Plan According to Roadex Design Methods, Roadscanners Oy 2009

4. Berntsen, G., Saarenketo, T. 2005. Drainage on low traffic volume roads, p. 54

APPENDIX

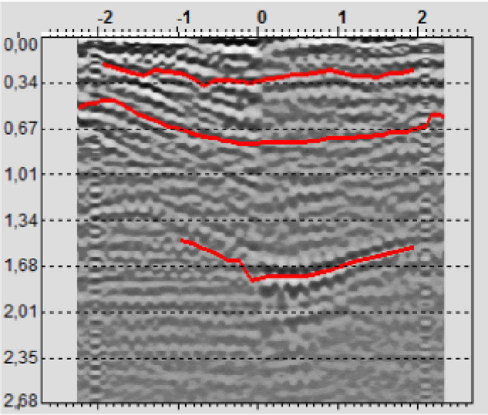
Appendix 1



Appendix 2

Road 16583, part 2

PL 3360

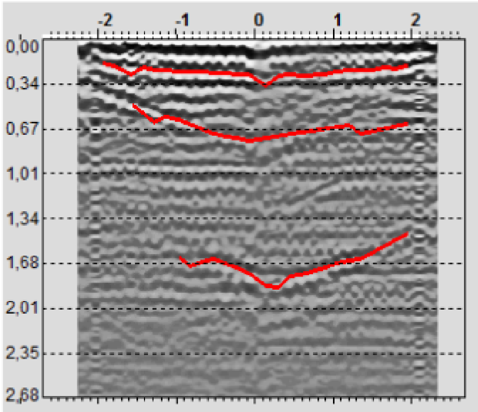


Highest line:
Wearing and base course

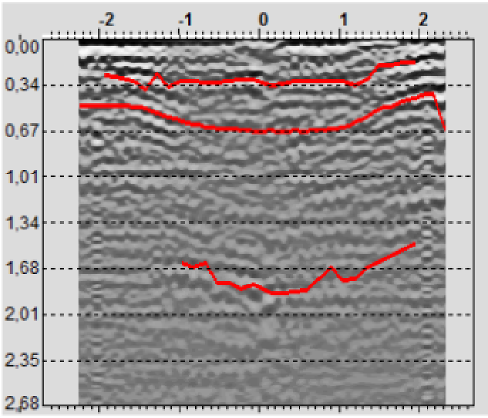
Middle line:
Lowest surface of the road structure

Lowest line:
Frost depth

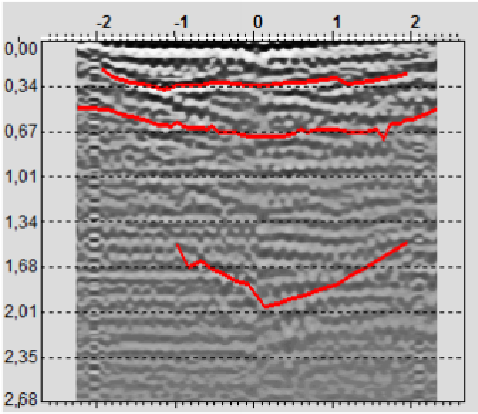
PL 3400



PL 3430



PL 3460



Roadscanners Oy. 05/2011

ROADEX PROJECT REPORTS (1998–2012)

This report is one of a suite of reports and case studies on the management of low volume roads produced by the ROADEX project over the period 1998-2012. These reports cover a wide range of topics as below.

- Climate change adaptation
- Cost savings and benefits accruing to ROADEX technologies
- Dealing with bearing capacity problems on low volume roads constructed on peat
- Design and repair of roads suffering from spring thaw weakening
- Drainage guidelines
- Environmental guidelines & checklist
- Forest road policies
- Generation of 'snow smoke' behind heavy vehicles
- Health issues raised by poorly maintained road networks
- Managing drainage on low volume roads
- Managing peat related problems on low volume roads
- Managing permanent deformation in low volume roads
- Managing spring thaw weakening on low volume roads
- Monitoring low volume roads
- New survey techniques in drainage evaluation
- Permanent deformation, from theory to practice
- Risk analyses on low volume roads
- Road condition management of low volume roads
- Road friendly vehicles & tyre pressure control
- Road widening guidelines
- Socio-economic impacts of road conditions on low volume roads
- Structural innovations for low volume roads
- Treatment of moisture susceptible materials
- Tyre pressure control on timber haulage vehicles
- Understanding low volume pavement response to heavy traffic loading
- User perspectives on the road service level in ROADEX areas
- Vehicle and human vibration due to road condition
- Winter maintenance practice in the Northern Periphery

All of these reports, and others, are available for download free of charge from the ROADEX website at www.ROADEX.org.